Rural electrification using Solar Photovoltaic technology based mini-grids in ecologically fragile and geographically inaccessible areas

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Project Brief

Project title	Rural electrification using solar photovoltaic technology based mini-grids in ecologically fragile and geographically inaccessible areas
Requesting country	India
Project type	Full Project
Duration	5 years
GEF implementing agency	UNDP
Executing agency	Ministry of Non-conventional Energy Sources, Government of India
Local implementing agency	WBREDA, Kolkata, and OREDA, Bhubaneshwar
Eligibility	India ratified the UNFCC in November 1993
GEF focal area	Climate change
GEF programme framework	Operation Programme 6, para 6.10 (d)

Summary

The project aims at developing and demonstrating a sustainable rural electrification model for ecologically fragile and geographically disadvantaged regions by using PV minigrids for decentralized generation and supply of electricity. The project design incorporates the following components in order to ensure the sustainability of the model:

- maximizing the local content *on the demand side* by integrating communities in planning, decision making, O&M, and ultimately in ownership, through the formulation of village committees;
- introducing innovative business approaches *on the supply side* through fee-for-service schemes using pre-paid cards as an option;
- ensuring the means to *finance the project*, by a combination of well-targeted and designed subsidies to take care of high up front costs of the PV-based rural electrification projects, and regular availability of microcredit to beneficiaries for starting income generation activities that will facilitate payment for services;
- *institutional strengthening* by setting up appropriate linkages for generation, sale, and supply of electricity; and
- *capacity building and enhancement* of electricity regulatory commissions, state nodal agencies, local entrepreneurs, NGOs, and other stakeholders to plan and implement similar projects.

The above rural electrification approach, which is service-delivery-driven, instead of technology-driven, will help in removing barriers for mainstreaming renewable energy technologies into the rural electrification process.

For the scope of the current project, two ecologically fragile regions have been selected. These are the Sunderbans and the Chilika Lake in the Indian states of West Bengal and Orissa respectively. Tribal communities whose only source of livelihood is the flora and fauna of these regions are the typical inhabitants. The Sunderbans, a part of the vast delta of the river Ganga, are characterized by mangrove swamps and islands interwoven by a network of small rivers, waterways, creeks, and tracts. Due to the geographical nature of the region, it is very difficult to extend a grid network to supply power to its 2.9 million population, spread over an area of 9629 sq. km, which traditionally has been depending on kerosene and diesel generating sets for its electricity requirements.

Similarly, the Chilika lake, which is the largest brackish water lake in Asia, consists of small islands. It is separated from the Bay of Bengal by a sand bar whose width varies from 100 m to 1.5 km. A 32 km long narrow outer channel connects the main lagoon to the Bay of Bengal. The lagoon is an estuarine one and it supports a unique ensemble of marine, brackish water, and fresh water species. The population in this region depends primarily on fishing. The region does not have any grid electricity. Diesel based generation is uncommon due to difficulty in the transportation of diesel.

Apart from Chilika, the state of Orissa has a 482 km long stretch of coastline covering over 8 districts. Most of the rivers open into the sea along this coastline. The back-water regions in the islands, in the estuaries and in between streams of rivers, have as many as 138 villages, all of which have a very fragile ecology.

The project will be implemented in 5 villages in Sunderbans region of West Bengal and 20 villages in the Chilika and the coastal regions in Orissa. The proposed duration of the project is five years.

Financing and leverage

	Million US $	Percent
Total project cost	**15.84**	**100**
GEF Financing	6.15	38.8
Co- financing		
MNES, GoI	5.0	31.5
State Government	1.48	9.4
Users/ beneficiaries	3.22	20.3

List of abbreviations

AC	Alternate current
AMC	Annual maintenance contract
B/W TV	Black and white television
BOS	Balance of systems
CFL	Compact fluorescent lamp
DC	Direct current
EPC	Engineering procurement construction
ERC	Electricity regulatory commission
ESCo	Electricity service company
GEF	Global Environment Facility
GoI	Government of India
GPU	Green power unit
GHG	Greenhouse gas
HDI	Human development index
IREDA	Indian Renewable Energy Development Agency
LT	Low tension
MNES	Ministry of Non-conventional Energy Sources
MW_p	Megawatt peak
NGO	Non-government organization
O&M	Operation and maintenance
OREDA	Orissa Renewable Energy Development Agency
PV	Photovoltaic
REA	Rural Electrification Association
RET	Renewable energy technology
SHS	Solar home systems
TA	Technical Assistance
T&D	Transmission and distribution
VC	Village committee
WBREDA	West Bengal Renewable Energy Development Agency
WTP	Willingness to pay

Note: For the purpose of this report, a conversion ratio of INR 48:USD 1 is taken

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1. Background and context

1.1 Rural electricity needs and present status of rural electricity services

The relationship between the energy and HDI (Human Development Index)[1] has profound implications on the strategy for poverty alleviation. Addressing the issue of poverty alleviation through the process of rural electrification has become a global agenda, because it is expected that rural electrification will provide:[2]

- Improved living standards (amenities and services)
- Reduced negative impact of energy use on health and local environment
- Increased employment (direct and indirect) on supply side (energy service delivery chain) and on demand side (rural industries, productive uses)
- Synergy benefits due to bundling of other infrastructural and developmental services

Rural electrification has been equated with village electrification schemes on the demand side, which have more or less focused on household lighting. Whether through Kutir Jyoti,[3] solar lantern or solar home lighting systems, the provision has only been for lighting. Rural electrification is not restricted to household lighting; it includes lighting for public places, power for commercial activities such as flourmill etc. On the supply side, rural electrification was understood as grid electrification and if grid extension was not viable, the rural areas continued to be denied with electricity.

At present, there are 80,000 villages in India that need to be provided with access to electricity. Out of these, 18,000 are remote and geographically inaccessible where grid extension is not economically viable.[4] As per the 2001 census, the number of such villages is likely to be considerably higher. According to an estimate, about 65% of the households in electrified villages do not receive the benefits of electricity even now. This is both on account of inability of households to afford electricity connections and the inability of electricity utilities to provide connections and supply power. The net result is that at least

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[1] The improvement of HDI has three crucial dimensions: equity based on a marked increase in access of poor to energy services; empowerment based on strengthening endogenous self-reliance; and environmental soundness. **Goals, Strategies and Policies for Rural Energy** by Amulya K N Reddy in *Economic and Political Weekly* December 4, 1999.

[2] **Expanding electricity access to remote areas: Off-grid rural electrification in developing countries** by Kilian Reiche, Alvaro Covarrubias and Eric Martinot in *WorldPower 2000*.

[3] The Kutir Jyoti programme launched in 1988, and implemented under the Rural Electrification Corporation, provided single point connections to rural poor households.

[4] 1991 census

70-80 million rural households still depend on kerosene lamps to meet a basic need such as lighting.[5]

1.2 Renewable energy technologies for rural electrification

Rural electrification of remote villages is a national priority. RETs (Renewable energy technologies) are considered a viable option and have been used for this application. Some of these technologies are biomass gasifier, small hydro, solar PV (Photovoltaic) and PV-wind-diesel hybrid systems. The Draft Renewable Energy Policy document of the Government of India envisages rural electrification, minimum rural energy needs, and decentralized energy supply for the agriculture, industry, commercial, and household sectors as thrust application areas. The MNES (Ministry of Non-conventional Energy Sources), being the apex institution in the country to coordinate all RET-based programmes, has been given the responsibility for rural electrification of the 18,000 villages where grid extension is not viable. In this new initiative, the MNES has identified about 14,000–15,000 villages that have solar PV as technically the most viable electrification option.[6] However, it has also been felt that though the country is poised to make a quantum leap in utilizing its vast renewable energy potential for the sustainable development of its rural population, it is inhibited in taking this leap due to several technological, institutional and financial barriers. The project intends to provide due assistance to remove these barriers through strategic interventions that will facilitate the mainstreaming of RETs for rural electrification.

2. Rationale and objectives

2.1 Objectives

The Global environmental objectives of the project are to reduce greenhouse gas emissions through the enhanced use of renewable energy in rural electrification.

Broad developmental goals of the project are to provide quality and reliable electricity services, and thereby inducing a sustainable growth in villages in geographically disadvantaged regions where grid extension is unviable.

The proposed project is designed to achieve the above goals through a barrier removal approach, and is therefore consistent with the GEF operation programme 6, para 10 (b) "Promoting the adoption of renewable energy by

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[5] Draft Tenth Five Year Plan (2002-2007) of the MNES, Government of India

[6] The selected villages for the proposed project belong to these 14-15,000 villages

removing barriers and reducing the implementation costs – wind, biomass, photovoltaics, small-scale hydro and other renewable energy for rural electricity supply".

The immediate objectives of the project at the national level are:

- To remove the barriers for decentralized generation based on renewable energy technologies for rural electrification through establishing proper institutional linkages and capacity building
- To develop and demonstrate a PV-based village minigrid model for sustainable rural electrification in ecologically fragile and geographically disadvantaged regions by incorporating market driven mechanisms on demand, supply and the financing side of the project.

In addition to the above, the project has the indirect objective to create an additional 1.5 MW_p demand for PV in the country that would provide commercial opportunities for local PV and BOS (balance-of-system) industry.

2.2 Rationale

2.2.1 Solar PV for rural electrification

Most PV projects, globally as well as in India, are based on SHS (solar home systems).[7] SHS, although technically well proven, replace kerosene and diesel only partially. They are ideally suited for domestic lighting, but have limited scope for income generating activities or overall community development, such as the provision of safe drinking water and vaccine refrigeration[8]. There are a few technological limitations as well, particularly related to the components. Due to the poor availability of high quality electronic and electrical spares in remote areas, the components are often of low quality and need frequent replacement. There is a risk of compromise on the quality of the battery against the costs during its replacement. Moreover SHS-based initiatives have not been able to end the sense of deprivation that prevails in the minds of the rural masses as far as supply of power is concerned. The high initial cost, the burden of maintaining it, and most often the absence of an effective maintenance mechanism, increase this sense of deprivation.

Approximately 21.9 MW_p PV systems had been installed for rural applications in the country till September 2001. Most of these systems are lanterns, home

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[7] As on September 2001, 1,80,000 SHS have been installed in India.

[8] SHS benefits those income generation activities that are based on enhanced lighting such as handicrafts. Minigrids, on the other hand, supply AC electricity that can be used for a variety of other applications such as motorised loads.

lighting systems, streetlights, and pumps. Only 1.2 MW_p are used in stand alone power plants, which provide electricity for various applications including commercial uses. Most of these power plants are designed to supply DC electricity, except 9 plants in Sunderbans that supply AC electricity. The experience with Sunderbans minigrids,[9] although not well documented, has already shown that it is possible to link activities for income generation with the provision of high quality and reliable electricity, and enable the beneficiaries to pay for the services. Minigrids supply 220 volts 50 Hz three-phase AC electricity through low-tension distribution networks to households for domestic power, commercial (e.g. shops, cycle repair shops, flour mills) activities, and community requirements such as drinking water supply and street lighting. They use state-of-the-art batteries and inverters to ensure long life and reliable field performance (typically 8-9 years for both battery bank and inverters). In the users' perception, it also has all the features of grid power supply, e.g. substation, overhead LT lines, service connections, tariff structure etc., that brings it close to the conventional power supply system. An appropriately designed minigrid can easily supply power for 8-10 hrs daily.

Although the MNES has made a commitment to provide power to 14,000–15,000 villages using PV in the next 10 years, due to limited financial resources, a single village can at most receive 2.5 kW_p of PV system for two light points in about 60 households, and 2-4 stand alone water pumps. It is clear from the above that, due to various constraints, the rural electrification initiatives in the country (planned as well as ongoing), are addressing only the minimum lighting requirement.

In addition to MNES efforts, the GEF has also co-funded two major initiatives supporting PV technologies in India. These are a line of credit to the IREDA, and the Photovoltaic Market Transformation Initiative. Both these initiatives are focussing on providing loan and finance facilities to consumers to buy PV systems. These are both equipment ownership models. By the very nature of these initiatives, they target end-user communities, which have a reliable source of income, and can purchase systems on an installment basis. However, these initiatives are aimed at enhancing the market penetration of PV systems; rural electrification is not the main objective. The proposed project through its fee-for-service model for rural electrification will compliment the previous GEF interventions by reaching out to a large segment of the population in

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[9] Power plants in Sunderbans, known as minigrids, are designed to supply AC electricity through localised grids.

geographically disadvantaged regions where other forms of modern electricity services may not reach.

2.2.2 Institutional infrastructure for effective rural electrification programmes

The electricity sector represented by SEBs (State Electricity Boards) in India, is characterized by financial mismanagement, high transmission and distribution losses, and huge cross-subsidies among other problems. The gaps between electricity supply and demand are widening because of poor cost recovery, managerial inefficiency, and inability to attract sufficient capital. The above have led to reforms being introduced in the electricity sector in most of the states. The ultimate objective of reforming the sector is to promote the development of an efficient, commercially viable, environmentally sustainable and competitive power industry which provides reliable quality supply at competitive prices to all consumers in the state, while becoming a net contributor to the state budget. However, the concerns that need to be addressed are: will those who do not have access to electricity, continue to be denied when the supply changes from a public to a profit-making business; and those who do have access, are they willing/able to utilize it. In other words, the question is how the sector reforms will influence the electricity services to the rural poor. The above concerns arise from three main issues/questions:

i) because of the high up-front cost of rural electrification options and low cash capacity of rural households, electricity distribution companies may not be willing to extend the electricity services to poor rural communities
ii) if renewable energy technologies are considered to be appropriate alternatives to rural electrification in villages where grid extension is not viable, whether distribution companies would be willing to consider these alternate options in their portfolio of services
iii) if MNES has the prime responsibility of providing electricity to the denoted 18,000 villages, what innovative interventions would be required for supply, demand, finance, institutional strengthening, and capacity enhancement, for an effective mainstreaming of RETs into the overall electrification process.

Past experiences indicate that government efforts at rural electrification based on RETs usually target only the provision of minimum energy for lighting and cooking, as they are limited by resource availability. They do not focus on linking the provision of electricity services with their productive use and with income generation. In addition, these programmes support the initial capital investment

only. Requirements such as those for replacing the battery, operation and maintenance, and the development of a market support infrastructure[10] get neglected. As a result, these initiatives are short-lived, do not provide reliable services to the community and hence, do not contribute towards the economic development of the region. Further, the SNAs (state nodal agencies) for energy development have traditionally been implementing all the MNES programmes in their respective states. The role of the local community has been minimal in planning or implementing these programmes. The SNAs are expected to play a key role in the newly proposed village electrification initiative along with NGOs, local entrepreneurs, and community organizations. Although the SNAs are experienced in implementing device-oriented subsidy-driven RET projects, they do not have any experience in implementing market-driven energy-service-oriented programmes that are designed on sustainable business approaches. The project proposes to develop the institutional arrangement with adequate linkages and capacity, for i) setting-up and O&M of the minigrid, ii) sale and supply of electricity services, and iii) activities for income generation.

2.2.3 Barriers to developing sustainable rural electrification models based on RETs

Although India has made considerable progress in the renewable energy sector, and simultaneously, efforts are also being made to achieve complete rural electrification, yet the mainstreaming of RETs in the rural electrification policies and programmes has not been achieved. So far, efforts have been made to demonstrate the technical viability of RET-based minigrid projects in one selected region – the Sunderbans in West Bengal.[11] Integrated business model for decentralized generation and supply, that can be adopted by the rest of the country, needs to be established. The concept has been demonstrated; the long-term sustainability of the programme has not yet been ascertained. The experience of using RETs for rural electrification is still limited to a project-wise approach. It has to reach a programmatic level in order to ensure the sustainability and replicability of such initiatives.

To identify the bottlenecks and specific barriers for sustainable rural electrification based on RETs, a preparatory phase was undertaken in three

[10] Market support infrastructure in this context refers to user awareness on the usage of electricity, supply and service of appliances, availability of trained and capable technicians, etc.

[11] At present there are 9 SPV-based and 2 Biomass-gasifier-based minigrids operational in the Sunderbans.

village clusters: one each in the Sunderbans in West Bengal, Chilika lake and the coastal belt of Orissa.[12] These regions are representatives of ecologically fragile regions anywhere in the world, yet they offer different scenarios in terms of their potential for linking income generation activities with the provision of electricity services, and experience with RET-based, particularly minigrid projects. Based on (i) a primary survey of approximately 5000 households spread over 26 villages, (ii) village level participatory meetings, and (iii) state and central level stakeholders' meetings, the following sets of barriers were identified.

Barriers related to the technology and the concept
▪ Limited experience with minigrids, yet limited dissemination of this experience, resulting in a lack of confidence among potential users ▪ No prior exposure to electricity usage, safety and precautions, conservation and management - a bottleneck to effective utilization of the minigrids ▪ Lack of an effective mechanism or device to monitor the use of electricity ▪ Lack of performance monitoring data and documentation of lessons learnt to modify the project design into a more efficient one ▪ Poor availability of energy efficient appliances.
Barriers related to institutional capacities and linkages
▪ No institutional linkages for inducing income generation with provision of electricity services ▪ Inadequate capacity in state-level institutions to design and implement the RET-based rural electrification programme ▪ Current support for RET-based initiatives for rural electrification does not provide linkages with other developmental programmes of the state ▪ Appropriate institutional linkages between the agencies identified to implement RET-based rural electrification, and that for grid-based electrification under the reforms scenario is not yet looked at ▪ An effective revenue collection model is not yet in place ▪ Involvement of local entrepreneurs, NGOs and the user community has been nil in rural electrification planning and implementation.
Barriers related to financing
▪ The current funding policy for RET-based initiatives only supports partial capital cost of the plant. Replacement of the battery, O&M, particularly of the distribution network, is not included ▪ Finance for users to invest in taking electricity connections, utilizing its benefits, and initiating income generation activities, is not available.

3. Project design

The project builds on the Sunderbans experience of utilizing RETs for environmentally sound rural electrification using minigrid model and, the primary survey of identified villages for understanding the load requirement and ability/WTP (willingness to pay) for the services. The WTP survey indicated that revenue collection from the sale of electricity at acceptable/affordable tariffs will not be sufficient to take care of the fixed cost of the power plant; it will only

[12] Please refer to the maps of the region in Annexure 1

finance the O&M costs. Considering the fact that rural electrification is a high priority agenda for the government, which is expected to ensure the provision of electricity services to rural areas, the project proposes to utilize the available subsidy instruments of the MNES for village electrification schemes.

The emphasis here is on demonstrating an integrated business model for decentralized generation and supply of electricity in selected village clusters, and facilitating its replication by the removal of specific barriers that have been identified. Following innovative approaches are suggested for achieving the above:

- Formulation of village committees with an objective to involve and integrate the local community in planning, decision making, O&M, and ultimately in co-ownership of the plant
- Introduction of free-for-service schemes using pre-paid cards as an option
- A combination of well-targeted and designed subsidies to take care of high up-front costs of the PV-based rural electrification projects, and ensuring availability of microcredit to introduce enterprises and household level income generation activities that will facilitate payment for services
- Setting up of appropriate institutional linkages for generation, supply, and sale of electricity
- Capacity building of electricity regulatory commissions, state nodal agencies, local entrepreneurs, NGOs and other stakeholders to plan and implement similar projects

The design of the project that evolved through the preparatory phase has two components:

i) Technology standardization, and proof of concept through 25 model demonstration projects in selected regions and
ii) Facilitation of replication and sustainability of the model through barrier removal measures.

The proposed duration of the project is five years.

3.1 Project boundary

The project boundary for the proposed project is the Sunderbans region in West Bengal, and the Chilika and coastal regions in Orissa. Villages identified for 25 demonstration projects are in:

i) Basanti and Gosaba blocks in Sundarbans region of the South 24 Parganas district, West Bengal

ii) Puri, Kendrapara and Jagatsinghpur districts in Orissa.

Once proven, the project model will benefit all villages that fall in the geographically disadvantaged areas in the country. These numbers are estimated to be 18,000.

3.2 Minigrid sizing and layout details

As per the survey,[13] village sizes in these regions typically fall in two categories, those having 150 or less households, and those having 300-350 households. The largest surveyed village has 392 households with a total population of 2064. The primary occupation of the households is fishing. About 94% of the households have land holdings up to 1 hectare *(they belong to the category of marginal farmers)*[14]. Majority of these households have their annual income in the range of 12,000 rupees (USD 250) per household.[15] The main energy requirement is for cooking and lighting, and the fuels used are cowdung, crop residue, fuel wood and kerosene. On an average, a family spends 150 rupees (USD 3.1) per month on kerosene for lighting. Although only a few households indicated their awareness of PV systems, all were willing to take electricity connections on a payment basis. Presented below is the list of income generation activities that are either currently existing and can be enhanced, or may be introduced based on the availability of electricity:

1 Spinning of cotton and muslin yarn
2 Weaving of cotton, muslin and silk
3 Mulberry silk reeling and weaving, dyeing and printing
4 Bee-keeping
5 Agarbatti making
6 Soap and detergent making
7 Jute crafts
8 Poultry and Duckary
9 Fish drying and preservation
10 Rice dehusking
11 Rope making

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[13] Annexure 2 has survey details of one representative village, names of 20 villages identified for project boundary in Orissa, and six representative villages in Sunderbans

[14] farmers having land holdings of up to 1 ha are called marginal farmers, more than 1 ha up to 2 ha are known as small farmers and, those having more than 2 ha of land holdings are called big farmers

[15] These families are above the Below Poverty Line category, which includes families having annual income of less than Rs. 6000

12 Tailoring and readymade garments
13 Small shops
14 Fishing net repair
15 Fruit and food processing
16 Cycle repair shop
17 Video cinema
18 Carpentry
19 Flour mill

The given activities, particularly those undertaken by women at home (item #1-12 in the above list) require enhanced and reliable source of lighting as quite a few of these are carried on at night after household chores are finished. Activities 15-19 represent motorized load.

The typical load requirement per household comprises 2–4 lighting points, one fan and one TV. The requirement for community applications include 3 kW_p for water pumping, 2 kW_p for street lighting, 1 kW_p for community centre, and 2 kW_p for a health centre equipped with vaccine refrigerator and provision for other applications as required. In order to optimize the size of the PV power plant, certain assumptions have been made for the demonstration phase. The optimization details are given in Annexure 3. Accordingly, a PV power plant of 50 kW_p installed capacity has been sized for a village with 150 households. The design takes care of the estimated increase in demand over a period of five years. From a 50 kW_p power plant, 30 kW_p power would be required for household lighting, 10 kW_p for community services, and 10 kW_p for entrepreneurial commercial activities. For a larger village, two power plants of 50 kW_p, (100 kW_p total installed capacity) could be installed. Further, PV plant being modular, the installed capacity can be enhanced with future increase in demand. For the scope of the current project, 25 minigrid models- 20 of 50 kWp and 5 of 100 kWp - are proposed. Out of the total 25 model projects, 20 would be demonstrated in selected village clusters in Orissa, and 5 in the Sunderbans, West Bengal.

4. Project components, activities and expected results

Based on the project design discussed above, the project activities can be broadly categorized into two: those related to demonstration and proof of concept mainly in regions in Orissa, and replication strategy through barrier removal in all the selected regions. Though different, both these sets of activities aim at developing an institutional model for the generation, sale, and supply of RET- based electricity for rural electrification, induce overall development and income

generating activities, and link them with payment collection. Once proven, the institutional model can be extended to all decentralized generation projects irrespective of the technological option.

4.1 Project components and activities

The project has two components:

1. Setting up 25 PV-based minigrids in selected villages/village clusters
   Sub components:
   A) technology standardization for PV based minigrids for decentralized generation and supply of electricity
   B) demonstration and evaluation of options for monitoring the use of electricity
2. Establish adequate institutional linkages and capacity building
   Sub components:
   C) setting-up and operation and maintenance of minigrids
   D) generation and sale of electricity (including revenue collection)
   E) income generation with provision of reliable electricity.

4.1.1 Component 1 – Setting up 25 PV-based minigrids in selected villages/village clusters

Sub component A: Technology standardization for PV-based minigrids for decentralized generation and supply of electricity

This component of the project targets the barriers related to the technology and the concept. It will standardize the design of the PV minigrid based on the electricity requirements of the village/ cluster of villages. Power plant design(s) will be standardized for all electrical, electronic and mechanical components, and plant layout details. In addition, detailed designs for power evacuation and distribution systems and internal wiring inclusive of end-use appliances will also be standardized. These designs, after being tested and verified through the model projects, will be ready for adoption to electrify villages in similar geographical conditions.

Activities

A1. Develop and standardize technical specifications for installed capacity and additional/ replacement requirements for PV, battery bank, and inverter based on the total existing and projected electricity demand in modules of 5-7 years

A2. Techno-economically evaluate available options at regional, national and international levels for all the components required for the power plant. and evacuation system

A3. Develop guidelines for component selection based on the activity above

A4. Develop performance guidelines for components as well as the entire minigrid, including an accepted deterioration in performance over time.

Outcome

A reference manual for designing minigrid technology packages in order to facilitate their replication in other parts of the state.

Sub component B: Demonstration and evaluation of options for monitoring the use of electricity

This component targets barriers that are related to limited experience and limited dissemination of the experience related to the use of electricity from PV minigrids. Further, it will prove that rural electrification using RETs is not limited to lighting alone. RET-based minigrids are capable of providing electricity for domestic, community and commercial applications in order to achieve overall development goals through the following activities:

- opportunity for income generation
- improved living conditions by avoiding the use of kerosene
- supply of clean drinking water, safety through well-lit streets, improved health services, community participatory activities in community centres/youth clubs etc.

An important activity of this component is to evaluate and adopt the best method / device for monitoring the use of electricity at the household level in view of the fact that the capacity to supply electricity by the RET power plant is limited. The pre-paid card is one option that will be evaluated.

Activities

B1. Set up minigrids in 25 selected villages as per the standardized design(s)

B2. Verify the performance of individual components and the minigrid as a whole according to the guidelines developed under this project

B3. Develop a module for a user-training programme on the use and conservation of electricity. Conduct a training programme and educate the user on the use of pre-paid smart cards for electricity consumption and monitoring and subsequently introduce them. Simultaneously, evaluate other means such as

load controlling device in a few minigrids. Compare the pros and cons of both the options and recommend one or both for similar initiatives

B4. Develop a user awareness campaign on the concept of RET-based minigrids as a viable alternative to grid-extension-based rural electrification. The campaign would include components of rural electrification such as lighting (both domestic and public), water pumping, health services, community activities and education. The campaign, as well as its method of delivery, would be standardized such that it can be used at the regional, national, as well as international level.

Outcome

Options and best practices for the judicious use of electricity.

4.1.2 Component 2 – Establish adequate institutional linkages and capacity building

Traditionally, the involvement of private sector, NGO and civil society has been negligible in rural electrification as this sector is characterized by top-down approach for planning and implementation. In the field of RET based initiatives, the only institutional set-up has been the state nodal agencies that are used to a target oriented and device based approach. Sustainability (economical, social, environmental) of the institutional arrangement has not been accorded a high priority in planning or implementing RET initiatives. This component of the project will design and set up an institutional arrangement as explained below: *(please refer to figure 1 for the same)*

Sub component C: Setting up and O&M of the minigrid

The setting up of power plants (consisting of a PV array field, battery bank, inverters, other BOS, and plant room), and their O&M, will be the responsibility of WBREDA and OREDA along with the EPC contractor in order to ensure reliable generation of electricity. The above will remain the property of the WBREDA and the OREDA for a pre-decided duration, after which the ownership may be transferred to a committee with stakeholders from WBREDA, the EPC contractor, and villagers. WBREDA and OREDA will utilize the existing funding instruments of the MNES to take care of the high up-front cost of setting up the PV power plant.

WBREDA and OREDA will subcontract the setting up of a supply and distribution network to private local enterprises through a process of competitive bidding. The capital investment for setting up the network will be subsidized by

the state through state and local level development funds. One of the criteria for awarding the contract would be a request for the lowest amount of subsidy from the state. The subcontractor will maintain the network for its contractual period, after which either the contract may be renewed or a new subcontractor may be selected, again through competitive bidding. This will be a fee-for-service model in which the enterprise will operate, maintain and collect the revenue from the sale of electricity services, thereby functioning as an ESCO (electricity service company). These two institutions, for generation and supply/distribution will be linked through an agreement that will include the tariff and its escalations over the contractual period.

Activities

C1. Involve the Gram Panchayat in project planning. Acquire the Panchayat land as a contribution from the community and complete all formalities, documentation etc.

C2. Formulate an agreement with the EPC contractor for supply, erection, commissioning and O&M of the power plant

C3. Identify and train local people who could be involved in the O&M of the power plant

C4. Evaluate local expertise to set up a distribution network and subcontract the activity to the most competitive offer.

Outcome

A guide for formulating the terms of reference, agreement, contracts, and institutional arrangements for setting up and O&M of the minigrid.

Sub component D: Sale and supply of electricity including revenue collection

Sale & supply

Electricity Regulatory Commissions have either already been set up in states, or are being established. Although the ERCs have no major role in the electrification of 18,000 unelectrifiable villages, they have to be sensitized towards rural electrification issues as these ERCs have certain statutory responsibilities and powers that may have an effect on rural electrification.

This sub-component of the project will develop an institutional mechanism, which will enable the WBREDA and the OREDA to undertake RET-based rural electrification within the regulator's guidelines. A separate unit called the GPU

(Green Power Unit) will be set up in the WBREDA and the OREDA, that will be solely responsible for generating and selling renewable-based electricity to those villages where grid extension is not viable.

Capacity building of the GPU to undertake this major responsibility and to ensure its smooth execution will form an important activity of this component. A few other elements of capacity building are the computation of electricity tariff, and the development and negotiation of agreements for the sale of electricity.

Revenue collection

In order to ensure community ownership and an effective revenue collection, the institutional arrangement will be developed along the model of a VC (Village Committee),[16] which will have stakeholders from power plant owners and electricity generators, enterprise responsible for supply/distribution, Gram Panchayats, electricity consumers, and NGOs involved in facilitating the development process. Capacity building and effectiveness of VCs will be ensured through a multi-stage process.

- At the first stage, the VC acts as a Consumer Care Centre in the village and facilitates interaction, education, grievance redressal, bill distribution, metering, and cash collection
- In the interim stage, a greater accountability is transferred to the VC by making it aware of the inputs at the transformer level and actual billing being achieved
- The energy accounting is completely transferred to the VC whereby it acts like a cooperative or electricity association: it will be billed on transformer reading as a bulk consumer and the entire responsibility of collection will be transferred to them.

Activities

D1. Conduct workshops for the SERC and other institutions associated with generation, and T&D of electricity, to sensitize them and make them aware of the renewables-based alternative for rural electrification

D2. Conduct study tours, both national and international, for WBREDA, OREDA and electricity regulators at the state and central levels to understand various institutional arrangements for similar initiatives

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[16] Study on Orissa Power Sector Reforms- Phase II. Pilot study conducted by Indian Institute of Ahmedabad, India for Power Grid Corporation, New Delhi, India. June 2001

D3. Develops framework for GPU (Green Power Units) for facilitating WBREDA and OREDA to generate and sell renewable-based electricity

D4. Organizes training programmes for the computation of tariff based on life cycle cost of operating and maintaining the power plant, cross-subsidy, installed capacity addition with increases in demand, maintaining the power evacuation system and sustaining the infrastructure required for revenue collection

D5. Organize stakeholder meetings and discussions to develop a mechanism for revenue collection and/or sale of pre-paid cards, and subsequently a framework for the formulation of Village Committees.

Outcome

Mainstreaming of renewables into the electricity planning process at the state level.

Sub component E: Income generation activities with the provision of electricity services

Although the role of access to modern energy in poverty alleviation is indisputable, very little empirical data is available that links the ability of RETs to deliver the level of services that will help in poverty alleviation. One of the reasons for the above is that enabling mechanisms are never created that will induce income generation activities to reduce poverty. For example, the provision of electricity alone does not ensure that every household will be able to start income generation activities. The supply of raw material, creating marketing channels for finished products, value addition to local handicrafts and skills, and techniques to utilize local resources are a few enabling mechanisms that need to be initiated in order to link the provision of services to poverty alleviation. To address this barrier, the project will develop the capabilities of Panchayati Raj institutions[17] and VCs to undertake the following activities:

Activities

E1. Identify NGOs and develop partnerships with them for their role in the overall development of the villages. Identify training needs of the NGO partners and develop appropriate training modules

E2. Training of NGOs as trainers to initiate micro enterprises such as supply and service chains for energy efficient appliances

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[17] Village level local governance entity.

E3. Facilitate the formation of SHGs (Self Help Groups) for women to start small household enterprises

E4. In order to facilitate the pace of other developmental activities such as access to road, primary health centres, community activity centres, media access, improved educational infrastructure etc., sensitization workshops will be held for agencies managing the other regional developmental funds, on how to link rural electrification with the overall infrastructural development of the region

E5. Set up a seed fund from the project resources that will be accessed by consumers for various purposes, such as internal wiring, purchase of energy efficient appliances, as capital for starting an enterprise, and by SHGs for their activities. After the successful management of the seed fund by the VC for the project duration, the fund may be transferred to the local bank, which would then manage the same in the future.

Outcome

Road map for sustainable economic growth of the village, linking it with the provision of electricity services.

4.3 Expected results

The project is expected to result in the following:

- Sustainable model for PV-based rural minigrids
- Demonstration of RET-based decentralized generation and fee-for-service supply options
- Awareness about productive use of electricity, electricity conservation and use of efficient appliances
- Linking income generation activities such as cycle repair, tailoring, video and entertainment, spinning yarn, weaving, and repair of fishing nets with the electricity service while preserving the biodiversity of the regions
- Capacity building at local level to conceive, develop and implement sustainable rural electrification projects
- Recommendations on rural electrification approaches in the context of reforms in the electricity sector
- CO_2 mitigation potential of 56,940 t, at 1898 t per 50 kW_p minigrid over 20 year life of the project.

4.4 Activity schedule

Year	1		2		3		4		5	
Project components and activities										
Component 1: Setting up 25 PV-based minigrids in selected villages/village clusters										
Sub component A Technology standardization for PV-based village minigrids for decentralized generation										
Sub component B Demonstration and evaluation of options for monitoring the use of electricity										
Component 2 : Establish adequate institutional linkages and capacity building										
Sub component C Setting-up and operation and maintenance										
Sub component D Generation and sale of electricity (including revenue collection)										
Sub component E Income generation with provision of reliable electricity										

Note. Year 1 is taken from the date of final approval

5. Risks and sustainability

5.1 Sustainability

The sustainability of this approach is ensured by removing technical, institutional, and financial barriers for PV-minigrid-based rural electrification, through the synergy of the following components:

i) Introduction of fee-for-service model for delivery mechanism;

ii) reduced implementation and O&M requirements over the years due to programmatic effect;

iii) income generation linked with provision of electricity;

iv) involvement of stakeholders in planning, implementing and ownership of the project;

v) capacity building and institutional strengthening for designing and implementing such projects; and
vi) creation of policy framework for rural electrification approaches under the reforms scenario.

Other than the carbon dioxide savings and access to electricity by a large rural population while preserving the biodiversity of the region, an important outcome of the project would be to demonstrate an alternate business model for rural electrification based on RETs. The project will establish the techno-commercial viability of RET-minigrids-based rural electrification, which can be replicated in all the villages that lie in geographically disadvantaged regions (assumed to be 18,000 in number) and do have easy access to other RET resources such as biomass, hydro, or wind. This model can be replicated globally to all similar villages in developing countries.

5.2 Risks and their mitigation

The project faces certain risks, one of them being the possibility of grid availability in mid term future which is defined as the period beyond 10 years. In the current context, the villages selected are those where grid extension is not viable. However, in mid term future technological advancements may make grid extension feasible. In such a scenario, the existing distribution network can be used to supply grid electricity. Alternately, the minigrid could be used for demand side management whereby the community would purchase grid electricity only during peak hours.

The project has an inherent risk related with parallel approaches for rural electrification and renewable energy development policies of the government. The project is based on the assumption that renewable technologies are viable options for rural electrification, and such initiatives are in accordance with national priority. The project design has taken into account that suitable linkages are created between the two sets of institutions that are responsible for rural electrification and renewable energy development.

Another risk is associated with the involvement of the regulator in fixing tariffs that may not be sensitive to the economics of RET power generation, particularly in Orissa, where reforms have been completed and the electricity distribution in the entire state is distributed to 5 private sector distribution companies. However, this risk has been minimized by the new initiative of village electrification of 18,000 unelectrifiable villages where the SNA will play a key role. The project empowers the SNA to plan, coordinate and implement the above

project, and sensitizes ERCs and private sector distribution companies towards mainstreaming RETs into the rural electrification process.

The sustainability of the project is based on a successful fee-for-service model, and hence it minimizes the risks associated with poor revenue collection. To ensure an effective revenue collection, apart from a survey of willingness-to-pay, the project has built in a component that links income generation and other benefits with the provision of electricity. This component would ensure that users are able to enjoy the benefits of electricity and hence are willing to pay for its services.

The following table summarizes the major project risks, their levels, and proposed mitigation measures.

Risk	Level	Proposed mitigation
Rural electrification policy non-conducive to renewables	Medium	The project will empower the WBREDA and OREDA to undertake turn-key renewables-based rural electrification and establish suitable linkages with ERCs
Inadequate utilization of electricity services	High	▪ User awareness on usage of electricity ▪ Linking the benefits of electricity with income enhancement ▪ Availability of energy efficient devices
Ineffective revenue collection	High	▪ Involvement of users through the VC ▪ Linking the benefits of electricity with income enhancement
Poor acceptance of concept by users	Low	▪ User awareness workshops ▪ Demonstration of model projects

6. Stakeholder participation and implementation arrangements

The project implementation proposes to involve MNES as the apex agency for execution and coordination of the project. Within MNES, the project proposes a special GEF cell for overall coordination of the project. At the state level, WBREDA and OREDA will implement the project respectively through separately formulated units called GPU, dedicated to coordinate and implement the rural electrification project. These agencies through their GPUs will be accountable to MNES, which in turn will be accountable to the UNDP for all the committed activities and project outcomes. The project at the field level will be coordinated and implemented by GPU Project Offices equipped with adequate resources e.g. manpower, vehicles, and computers for their effective functioning. Figure 2 presents the implementation arrangements for the project.

Other state level partners in the implementation of the project are the state electricity regulatory commissions, electricity distribution companies and the district administration. Local vendors for the supply of components/setting up of distribution network and energy efficient appliances would be involved at the

project level. At the village level, the village panchayat, NGOs and consumer groups would be important stakeholders. Other stakeholders in the project are the industry for the supply of modules, battery and other BOS components, and local entrepreneurs, to set up and maintain the distribution network.

7. Incremental costs and project financing

7.1 Project baseline

In the project boundary defined above, the current baseline is either no provision of electricity or, in some villages, diesel-generator-based battery charging or electricity supply. However, in the absence of a reliable electricity supply, the potential for economic growth of the region has not been utilized. Kerosene is the most common fuel used for lighting. The activities that contribute to the socio-economic development of the village, such as education, health, safety, entertainment, infrastructure, and domestic enterprises remain underdeveloped as they depend critically on improved access to electricity.

7.2 Incremental cost analysis and project financing plan

The approach followed for incremental cost analysis is based on the assumption that PV-minigrid-based rural electrification will be sustainable, once the barriers are removed with the support of the GEF.

The up-front capital cost of setting up proposed PV minigrids is higher than the baseline, which is diesel generator-based supply of electricity. The cost of the baseline option on a life cycle basis for supplying equivalent electricity is estimated to be US$ 9.69 million. The cost of setting up 25 PV minigrids is estimated to be US$ 13.84 million. The difference of US$ 4.15 million is taken as incremental cost component for setting up minigrids. In addition to the above, technical assistance fund from the GEF related to the removal of barriers is estimated to be US$ 2.0 [18]. The total increment cost for the project is estimated to be US$ 6.15 million.

The total cost of the project based on the life cycle cost of PV minigrids, and cost of barrier removal, is calculated to be US$ 15.84 million. The MNES is proposing to co finance US$ 5.0 million, primarily towards funding equipment for the PV power plant. In addition, state is co-financing US$ 1.48 million towards setting up a distribution network. Users are willing to pay an initial

[18] The technical assistance component for barrier removal, other than the model demonstration projects, will be shared equally between the two states. Financing (including co-financing) for model demonstration projects will be shared by the two states in proportion to their respective minigrids.

deposit and monthly charges on the consumption of electricity.[19] The user contribution is therefore US$ 3.22 million. The project proposes to GEF to finance the remaining component of US$ 6.15 million *(Please refer to annexures 4 & 5 for the detailed project financing and incremental cost analysis respectively).*

7.3 Carbon dioxide mitigation potential

The carbon dioxide mitigation potential of the project within its boundary (25 selected villages) and lifetime of 20 years is expected to be 56,940 t. The cost of CO_2 mitigation is calculated to be US$ 107.93 per t.

7.4 Project budget (US $)

Project budget (US $)

A. Project Costs

Year	1	2	3	4	5	Total
Technical assistance						
Component-1	112000	70000	18000			200000
Component-2	714000	460000	174000	242000	210000	1800000
Installation of minigrids	6920000	6920000				13840000
Total	7746000	7450000	192000	242000	210000	15840000

B. Project financing plan (m US$)

Cost for setting up model projects	13.84
TA for barrier removal	2.00
Total project costs	15.84
GEF Financing	6.14
MNES co financing	5.00
Other co financing (user)	3.22
Other co financing (state)	1.48

[19] a) During the survey, target users have indicated their willingness to pay Rs. 2500 (US$ 52.1) towards initial application and internal wiring charges. In addition, they are willing to pay electricity charges roughly equal to their monthly expenditure on kerosene, that is, Rs.150 (3.1 US$). In a few villages in the Sunderbans, shopkeepers hire 60 W bulb connections from the local diesel generator operator and pay Rs. 5 (10.4 cents) daily for the usage of 5 hrs.
b) In order to convert their willingness into an ability to pay for initial charges, provision has been made in the project design that will enable users to take the short-term credit from the VC from the seed money kept with them for this purpose
c) In the project design, it is assumed that the revenue from the sale of electricity to commercial entities will compensate for the consumption of electricity, free-of-charge, for community applications such as street lights, drinking water etc.

8. Monitoring, evaluation and dissemination

The project monitoring has been carefully planned through a set of procedures designed at the local and central levels, details of which are given in the project planning matrix in Annexure 6.

- At the local level, the records of generation and sale of electricity will be maintained that, at any given point in time, will be able to indicate the level of technical performance of the project. In addition, the VC will act as the single-point contact between the consumers and GPU-WBREDA/ OREDA and will maintain a record of all complaints, grievances and redressal at the local level.
- At the user end, a record of monthly billing will indicate the rate of usage and benefits of electricity. Regular six monthly surveys will evaluate the economic growth induced by the provision of electricity. NGOs will be identified to conduct these surveys that will evaluate the sustainability of the project.
- MNES, through a special cell for rural electrification, along with GPU-WBREDA and OREDA , will monitor the progress of the demonstration projects.
- In addition to the above, a national level team of experts, through a steering committee, will evaluate the project progress and its impact on a yearly basis for the entire duration of the project. This team will document the results and lessons learnt as a case study that will be available for reference at the global level.

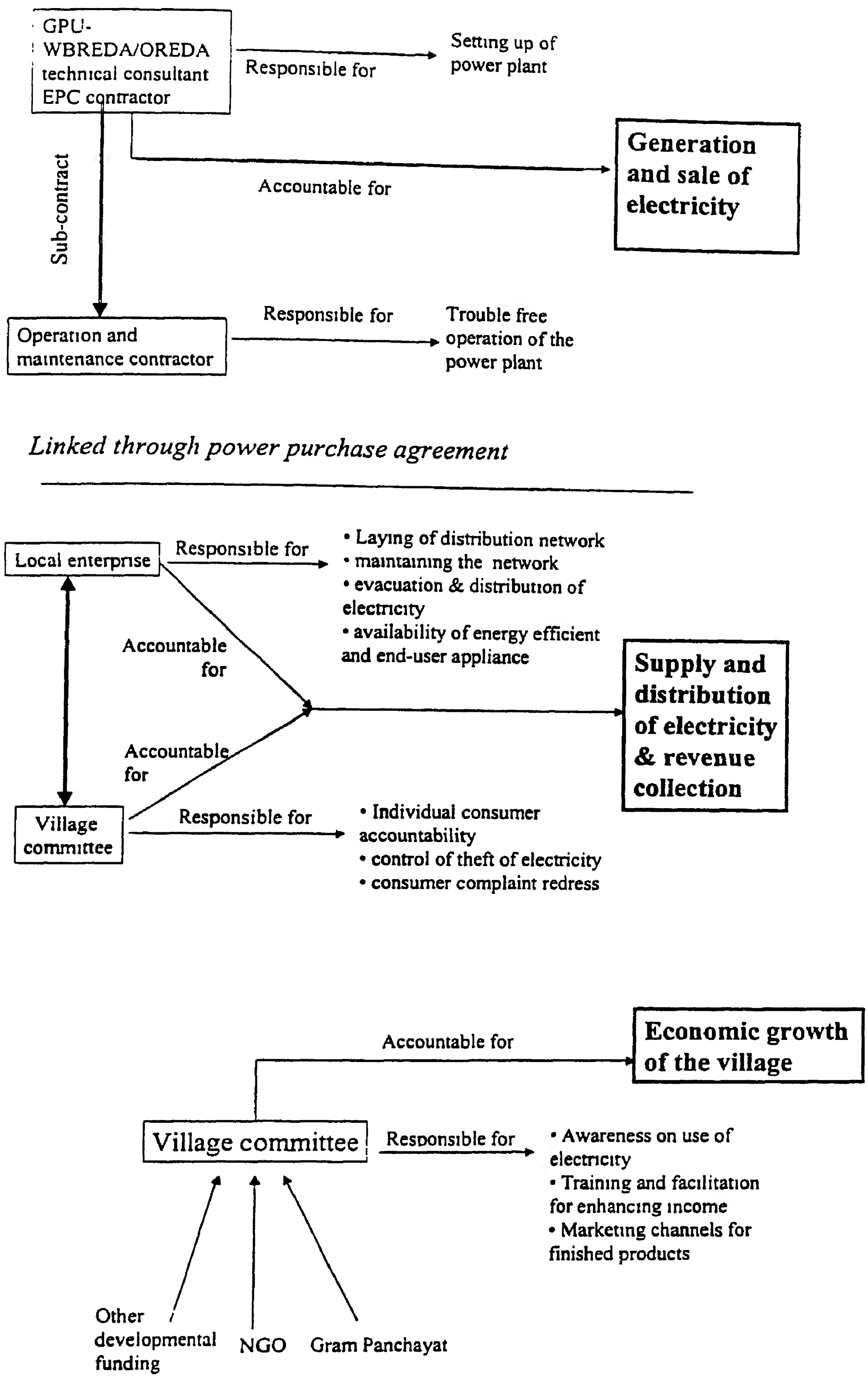


Figure 1. Institutional linkages

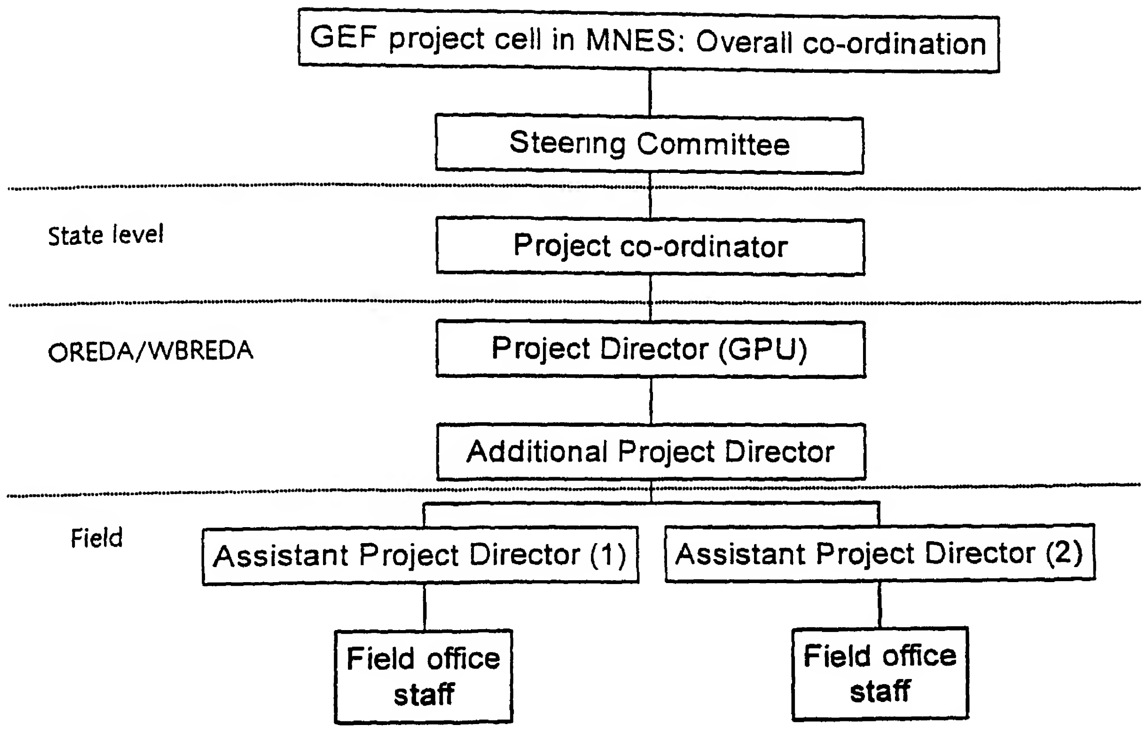
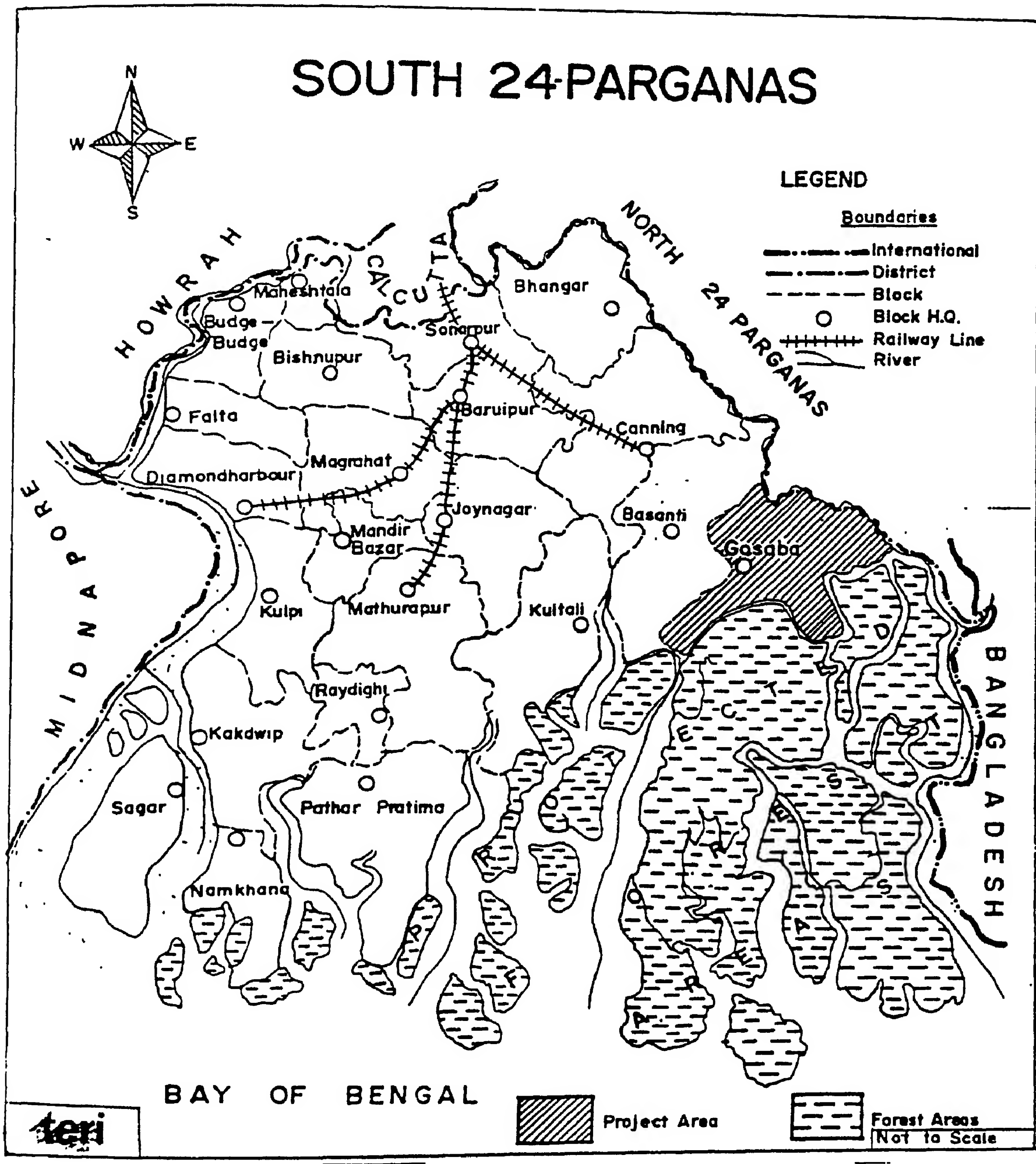


Figure 2. Implementation arrangements

Annexure 1


SOUTH 24-PARGANAS
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Maheshtala
Budge-Budge
Bishnupur
Sonarpur
Bhangar
Baruipur
Canning
Falta
Magrahat
Diamondharbour
Joynagar
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Mandir Bazar
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Project Area
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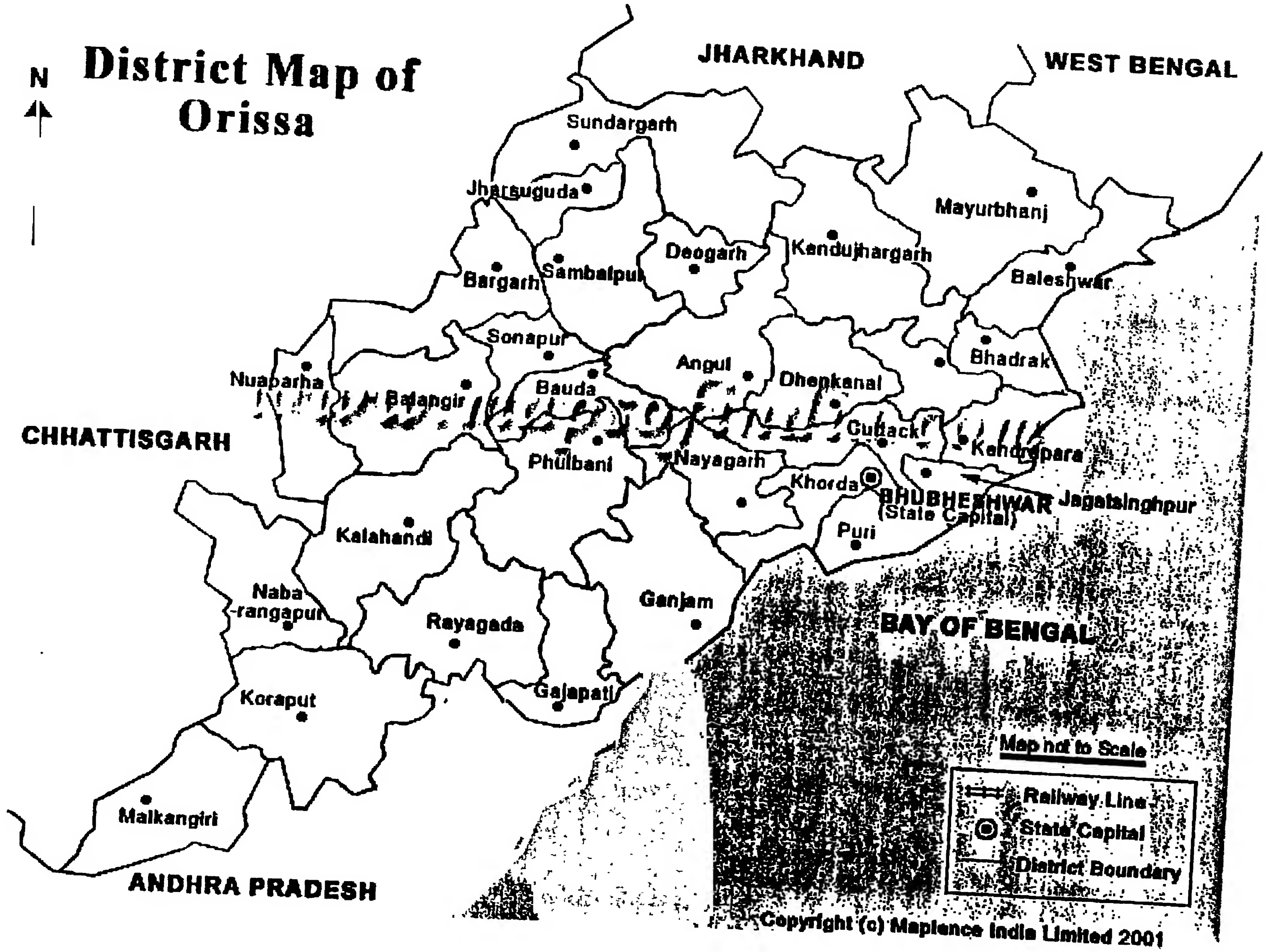
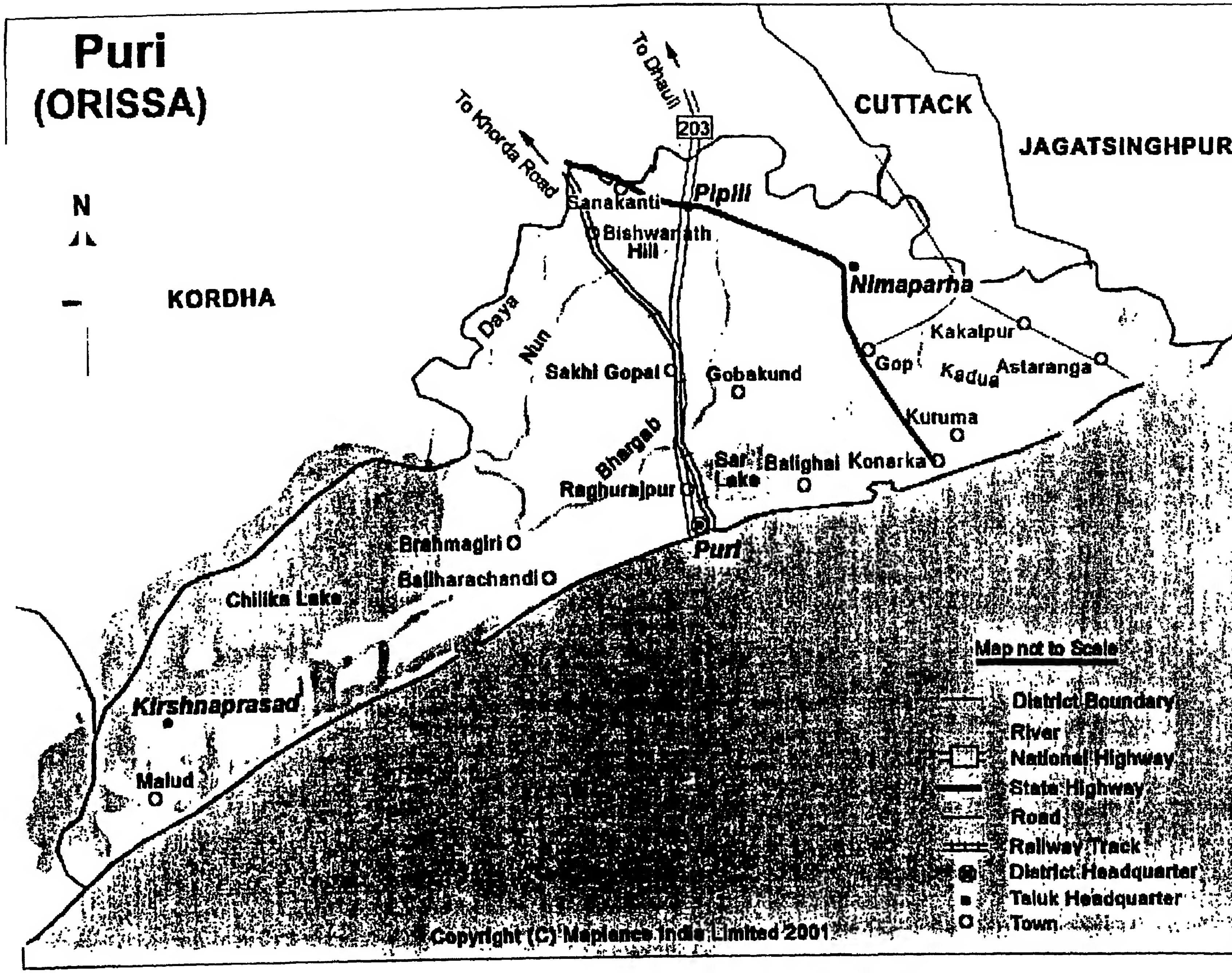
District Map of Orissa

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Astaranga
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Sakhi Gopal
Gobakund
Kuruma
Bhargab
Sar Lake
Balighai
Konarka
Raghurajpur
Puri
Brahmagiri
Balharachandi
Chilika Lake
Kirshnaprasad
Malud
Map not to Scale
District Boundary
River
National Highway
State Highway
Road
Railway Track
District Headquarter
Taluk Headquarter
Town
Copyright (C) Maplance India Limited 2001

Annexure 2: Village details

Sl No.	Village name	Gram panchauat	District	Police station and Block name	J.L No.	Population covered (nos.)	Total household/ family (nos.)
State: West Bengal							
1	Shibganj	Bharatgarh	South 24 Parganas	Basanti	160	2239	330
2	Purbabayar Singh	Chunakhali	South 24 Parganas	Basanti	62	2104	385
3	Sachiakhali	Chunakhali	South 24 Parganas	Basanti	63	1141	253
4	Manasakhali Kacharibari	Fulmalancha	South 24 Parganas	Basanti	64	571	120
5	Manasakhali Khashchak	Fulmalancha	South 24 Parganas	Basanti	64	1080	225
6	Pathankali Khashchak	Pathankhali	South 24 Parganas	Gosaba	76	1539	296
State: Orissa							
1	Balidihi	Nagar	Puri	Astarang		2064	392
2	Kaliakana	Nagar	Puri	Astarang		484	69
3	Nuakaliakana	Nagar	Puri	Astarang		486	104
4	Dihakarada	Talada	Puri	Astarang	11	1187	178
5	Edbansa	Talada	Puri	Astarang	10	916	163
6	Paikhala	Talada	Puri	Astarang	9	653	118
7	Raisol	Talada	Puri	Astarang	12	480	76
8	Talada	Talada	Puri	Astarang	8	1665	314
9	Mainsa	Behrampur	Puri	Krushnaprasad		966	137
10	Brahmapur	Behrampur	Puri	Krushnaprasad		1746	328
11	Suankana	Korua	Jagatsinghpur	Naugaon	91	346	46
12	Tarasahi	Tarasahi	Jagatsinghpur	Balikuda	221	2830	440
13	Ahiraipur	Rangani	Kendrapara	Rajnagar	25	536	88
14	Pravati	Rangani	Kendrapara	Rajnagar	26	380	80
15	Anantakesari	Rangani	Kendrapara	Rajnagar	28	307	68
16	Dolasahi	Rangani	Kendrapara	Rajnagar	32	571	119
17	Banipal	Rangani	Kendrapara	Rajnagar	33	635	95
18	Keruapal	Rangani	Kendrapara	Rajnagar	34	999	159
19	Giriapahi	Rangani	Kendrapara	Rajnagar	35	607	92
20	Gartta	Rangani	Kendrapara	Rajnagar	39	916	149

Annexure 3: Assumptions for preliminary power plant sizing

Total number of households	150
Connected load per household	100 Watts*
Total connected load at maximum utilisation	25 kW_p
Daily demand pattern	1800–2250 hrs
Average daily electricity consumption	112.5 kWh
Average annual electricity consumption	41,000 kWh
Average annual electricity production from the power plant	73,000 kWh
Available energy for community and commercial applications	32,000 kWh

*assumed that out of 150 total households, 100 households that have taken 100 W connections initially, will apply for 100 W more, thus loading the plant to a maximum capacity of 25 kWp.

Annexure 4

Budgetary estimates per state (in US$) for Technical Assistance component

Technical and other professional consultancy- @2500 pmm lumpsum	2500
manpower (local) rates +overheads- @1000 pmm	2000
International travel @ 4000 per person	4000
Domestic travel @ 1000 per person	1000
Events @4000 per event	4000

Year	1	2	3	4	5
Component 1- setting up 25 PV based minigrids in selected villages/ village clusters					
Baseline (experience of sunderbans)	**9000**	**9000**	**9000**		
Consultancy	10000	5000			
Manpower local	12000	16000	8000		
Travel-international	16000				
Travel- domestic	4000	2000	2000		
Hardware	5000	5000			
Software	10000				
Events	8000	16000	8000		
Others					
Total	***65000***	***44000***	***18000***		
Budget required (total-baseline)	**56000**	**35000**	**9000**		
Grand Total	**100000**				

Component 2-Establish Institutional linkages and capacity building					
Baseline	**0**	**0**	**0**	**0**	**0**
Consultancy including NGO involvement	5000	10000	10000	15000	15000
Staff salaries at all level	16000	20000	20000	20000	20000
Office infratructure at all level	150000	120000	0	0	0
Travel- international	0	32000	0	16000	0
Travel- domestic	10000	14000	15000	20000	20000
Training programmes and other events	16000	24000	32000	40000	40000
Seed fund for to consumers	150000				-
Overheads and other costs	10000	10000	10000	10000	10000
Total	***357000***	***230000***	***87000***	***121000***	***105000***
Budget required (total-baseline)	**357000**	**230000**	**87000**	**121000**	**105000**
Grand Total	**900000**				

Annexure 5: Incremental cost matrix

Project Components	Baseline scenario	Alternative scenario	Increment
1. Setting up 25 PV based minigrids in selected villages/village clusters			
A. Technology standardization for PV based village minigrids for decentralized generation.	Optimum design for PV minigrids on availability of local resources, and global technology assessment has not been done. No performance evaluation and monitoring data available to understand the effectiveness of existing PV minigrid projects	Complete technology package for installed and additional/ replacement requirements, including guidelines for component selection are developed and standardized. Performance guidelines at components and minigrids level are developed	A reference manual for designing PV minigrid packages will be available for replication with minimum efforts in similar regions in the country, and at global level
Costs	US$ 54,000	US$ 254,000	US $ 200,000
B. Demonstration and evaluation of options for monitoring the use of electricity in model projects.	Majority of the RE based Rural electrification efforts till now have been limited to provision of devices for household lighting. Diesel generator continues to be source of electricity. Villagers are not aware of the pros and cons of using RET based electricity. Without proper understanding, the tendency for theft, misuse of electricity services is high	A comprehensive approach to RE based rural electrification through 25 minigrids is demonstrated, showing that RE based electrification is not limited to household lighting. Beneficiaries and policy makers' confidence in RET based rural electrification is enhanced.	Best practices and options for judicious use of electricity is available to ensure the reliable performance and effective electricity utilization from the RET minigrids
Costs	US$ 9,690,000	US$ 13,840,000	US$ 4,150,000

Project Components	Baseline scenario	Alternative scenario	Increment
2. Establishing adequate institutional linkages and capacity building			
C. Setting up, and O&M of the minigrid	Private sector, NGOs and civil society's role has been negligible in rural electrification. The sense of ownership, community responsibility for proper usage of the services, lack of mutual confidence between the service provider and beneficiaries, etc are some of barriers State agencies responsible for implementing RET projects are used to device oriented target driven programmes where sustainability of institutional arrangement has not been accorded a high priority	Key officials in WBREDA and OREDA will be trained to undertake and implement RE based rural electrification in their respective states. Specific capacity building will focus on procurement, supervision during installation and commissioning, and AMCs procedures for setting-up and maintaining the generating facility along with the equipment supplier. Local people will be trained to involve them in O&M of the plant.	Guidelines for formulating the terms of reference, agreements, contracts, and institutional arrangement for setting up ,and O&M of the minigrid
D. Sale and supply of electricity including revenue collection	No clear guidelines or directions have been drawn that will mainstream the procedures for tariff setting, licensing and other procedures for rural electrification using RET under the reforms scenario	Framework for institutional linkages will be set up and demonstrated in two states with an objective to empower the state energy development agencies for generation and selling of RET based electricity within the regulator's guidelines. ERCs will be sensitized to understand the limitations/ advantages of RE based rural electrification Village Committee will be formed for an effective revenue collection	RET based Rural electrification will become an integral part of electricity planning at state level

Project Components	Baseline scenario	Alternative scenario	Increment
E. Income generation activities with provision of electricity	Target beneficiaries are unaware of the usage and benefits of electricity. In the absence of systematic efforts at inducing economic growth such as agriculture, spinning and weaving, tailoring etc., the available electricity services are used only for entertainment purposes. Potential for economic growth based on local resources remain untapped as facilitating mechanisms such as marketing channels, raw material supply are not in place	Village Committee, Panchayat and NGOs are trained and then involved in identifying, and developing activities that will induce additional income for the beneficiary, and training the beneficiaries in adopting these activities	Roadmap for sustainable economic growth of the village linking it with the provision of electricity services
Costs	US$ 0	US$ 1,800,000	1,800,000
6. Global environmental benefits	Rural population in geographically disadvantaged areas is deprived of access to modern electricity, continues to use kerosene and diesel	Availability of reliable and clean electricity for lighting, entertainment, community development and income generation, not only in 18,000 villages in India, but also globally	Significant GHG emission savings are attained through avoided usage of 56940 t of CO_2 A sustainable business model for minigrids based Rural electrification is developed that can be adopted for global initiatives such as the G8 task force on renewable energy
7. Domestic benefits	Rural electrification implementation schemes remain ineffective and underutilized 25 target villages remain either i)without access to electricity and hence, no opportunity for socio-economic development, or ii) depend on diesel generator	Effective implementation of rural electrification initiatives through enhanced user awareness, stakeholder's participation, private sector and local entrepreneur's commitment	Sustainable socio-economic and environmentally friendly growth of the region and overall infrastructural development
8. Costs	**US$ 9,744,000**	**US$ 15,894,000**	**US$ 6,150,000**

Annexure 6: Project planning matrix

Narrative summary	*Objectively verifiable indicators*	*Means of verification*	*Critical assumptions*
Developmental Objectives (Goals)			
To reduce GHG emissions through the enhanced use of renewable energy in providing quality and reliable electricity services, and thereby inducing a sustainable economic growth in villages.	Number of villages being benefited by modern electricity services Reduction in use of conventional fuels in rural areas	Government statistics and planning records	Globally, renewable energy continues to get support as a clean-climate mitigation option Renewable energy will provide modern electricity services that will induce economic growth in village
Immediate Objectives (Purposes)			
To remove the barriers for decentralized generation based on renewable energy technologies for rural electrification through establishing proper institutional linkages and capacity building and, to develop and demonstrate a PV-based minigrid model for sustainable rural electrification by incorporating market-driven mechanisms on demand, supply and financing aspects, in ecologically fragile and geographically disadvantaged regions where grid extension is not viable.	Rural electrification policies and planning include PV-based minigrids as a viable option Share of PV minigrids in the portfolio of technology generation options at country level increases	Evaluation of rural electrification programmes PV industry statistics on demand and supply at the local level	Rationale and context are valid Findings of the preparatory phase hold good Grid extension continues to be non-viable in these regions
COMPONENT 1: SETTING-UP 25 PV-BASED MINIGRIDS IN SELECTED VILLAGES/ VILLAGE CLUSTERS			
Sub-component A: Technology standardization for PV-based minigrids for decentralized generation and supply of electricity			
Activities A1. Develop and standardize technical specifications for installed capacity and additional/replacement requirements for PV, battery bank, and inverter based on the total existing and projected electricity demand in modules of 5-7 years A2. Techno-economically evaluate available options at the regional, national, and international levels for all the components required for the power plant and evacuation system A3. Develop guidelines for component selection based on the activity above A4. Develop performance guidelines for components as well as the entire minigrid, including an accepted deterioration in performance over time.	Reference manual for designing minigrid technology packages Reduced planning efforts and implementation costs for new projects	Dissemination and use of manual Evaluation report of the manual Comparison of performance evaluation results with developed guidelines Sales figures of major components used in minigrids	PV is one of the most viable renewable technology options The reference manual is pragmatic, user friendly, disseminated, and used effectively by all stakeholders Technology assessment for all major components remains in tune with technology trends in the near and medium-term future

Narrative summary	*Objectively verifiable indicators*	*Means of verification*	*Critical assumptions*
Sub-component B: Demonstration and evaluation of options for monitoring the use of electricity			
Activities B1. Set up minigrids in 25 selected villages/village clusters as per the standardized design(s) B2. Verify the performance of individual components and the minigrid as a whole according to the guidelines developed under this project B3. Develop a module for a user-training programme on the usage and conservation of electricity. Conduct the training programme and educate the user on the use of pre-paid smart cards for electricity consumption and monitoring, and subsequently introduce them B4. Develop a user-awareness campaign on the concept of ret-based minigrids as a viable alternative to grid-extension-based rural electrification.	Number of households connected to the minigrid supply Units of electricity generated and consumed Cases of over-consumption and thefts Field performance evaluation of the power plant Sale of energy efficient appliances and pre-paid cards Reduced consumption of kerosene for lighting and diesel-based electricity Significant number of user training programmes being organised	Pre-scheduled monitoring of project progress in terms of tendering, procurement, installation etc. Electricity generation and consumption records Public distribution system records for kerosene Feedback from local entrepreneurs selling appliances Figures for transportation and sale of diesel Monitoring of business of private diesel generator based electricity service providers Schedule and programme details of all organized events	Users aspire for electricity services Users value electricity services for benefits such as in school education Users adapt to high technology gadgets such as pre-paid cards
COMPONENT 2: ESTABLISH ADEQUATE INSTITUTIONAL LINKAGES AND CAPACITY BUILDING			
Sub-component C: Setting up and O&M of the minigrid			
Activities C1. Acquire the panchayat land as a contribution from the community C2. Formulate an agreement with the equipment supplier for supply, erection, commissioning and O&M of the power plant C3. Identify and train local people who could be involved in O&M of the power plant C4. Evaluate local expertise to set up a distribution network and subcontract the activity to the most competitive offer.	Guide for formulating the terms of reference, agreement, contract and institutional arrangement Local people involved in O&M	Similar framework of institutional arrangements in all future projects Local employment records Dissemination statistics of the guide	Industry identifies a good market opportunity and responds to suggested institutional linkages Local community finds an employment opportunity

Narrative summary	*Objectively verifiable indicators*	*Means of verification*	*Critical assumptions*
Sub-component D: Sale and supply of electricity including revenue collection			
Activities D1. Workshops for the state electricity regulatory commission and other institutions associated with generation, T&D of electricity, to sensitize them and make them aware of the renewables-based alternative for rural electrification D2. Study tour for WBREDA, OREDA and electricity regulators at state and central level to understand various institutional arrangements for similar initiatives D3. Framework for Green Power Unit to be developed to facilitate WBREDA and OREDA to generate and sell renewable-based electricity D4. Training programme for the computation of tariff based on life cycle cost of power plant and evacuation system, subsidy, and capacity addition with increases in demand, and sustaining the infrastructure required for revenue collection D5. Organize stakeholder meetings and discussions to develop a mechanism for revenue collection and/or sale of pre-paid cards, and subsequently derive a framework for a village committee	Number of workshops, training programmes, study tours being organized Formulation of GPU in WBREDA and OREDA Professional satisfaction and sense of challenge among staff in WBREDA and OREDA Revenue collection mechanism in place VC is formulated	Schedule and programme details of all organized events Direct verification and feedback from participants Direct interaction with staff of WBREDA and OREDA Revenue collection records Meeting records and activities of the GPU and VC	Stakeholders appreciate the objectives of the capacity building measures and interaction with them is effective Workshops and training programmes generate interest among target audience and get valuable inputs from them Trained officials from concerned agencies stay in service to fulfill their commitment Users are willing to form an association Revenue collection terms are acceptable to users
Sub-component E: Income generation activities with provision of electricity services			
E1. Identify NGOs and develop partnerships with them for overall development of the villages. Identify training needs of the NGO partners and develop appropriate training modules E2. Facilitation for formulations of self help groups E3. Training of NGOs as trainers to initiate micro enterprises such as supply and service for energy efficient appliances E4. Workshops for linking other developmental programmes with rural electrification E5. Set up a seed fund capital and built capacity of VC to manage the same	Significant number of households using electricity for economic activity Increase in household income New enterprises and business Utilization of seed fund, development funds and new schemes for overall development of the region	Mid-term evaluation and survey Number of NGO members involved in the project District level records and statistics on expenditure on developmental work Significant number of applicants for credit from seed money	NGOs are interested in associating with the project Sufficient demand is created to sustain local entrepreneurship in business for energy efficient appliances. Credit from seed capital is utilized for what it is meant